

Agricultural Adaptation to Climate Change: Issues of Longrun Sustainability. By David Schimmelpfennig, Jan Lewandrowski, John Reilly, Marinos Tsigas, and Ian Parry; with contributions from Roy Darwin, Zhuang Li, Robert Mendelsohn, and Tim Mount. Natural Resources and Environment Division, Economic Research Service, U.S. Department of Agriculture. AER-740.

Abstract

Early evaluations of the effects of climate change on agriculture, which did not account for economic adjustments or consider the broader economic and environmental implications of such changes, overestimated the negative effects of climate change. This report, which highlights ERS research, focuses on economic adaptation and concludes there is considerably more sectoral flexibility and adaptability than found in other analyses. The report frames the discussion of economic adjustments within the context of global agricultural environmental sustainability.

Keywords: global warming, adaptation, longrun sustainability

Acknowledgments

The authors wish to thank Curtis Jolly, Susan Riha, and Gary Yohe for helpful discussions and reviews; and participants in the Natural Resources and Environment Division (NRED) seminar series, the NRED management reviews of commissioned products, and the Central Action Group of the Agricultural Economics Association of South Africa. It was a pleasure working with editor, Dale Simms, production assistant, Olivia Wright, and graphic designer, Vic Phillips. The foundation for this report is earlier work by former ERS colleagues Neil Hohmann, Sally Kane, and Jim Tobey.

Preface

This report summarizes and synthesizes results from several studies on agricultural impacts of climate change conducted within ERS or through cooperative agreements with university collaborators. These included agreements with Cornell University, Yale University, Auburn University, University of California at Berkeley, Purdue University, and Wesleyan University. Principal investigators under these agreements included Duane Chapman, Curtis Jolly, Harry Kaiser, Robert Mendelsohn, Tim Mount, William Nordhaus, and Gary Yohe. These studies were conducted with funding identified as part of the U.S. Global Change Research Program. Published studies conducted or funded, in part, by ERS that are the basis of this report include:

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- We thank Roy Darwin, Zhuang Li, and Robert Mendelsohn for contributions of new material to highlight specific points made in this report.

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Summary

The costs and benefits of climate change cannot be evaluated independently of behavioral, economic, and institutional adjustments engendered by changing climate. There remains scientific controversy about the nature and rate of climate change, but most scenarios suggest gradual change over decades, thus providing the opportunity for farms and other parts of the agricultural system to adapt. In addition, the time scale of 80 to 100 years makes other profound social changes inevitable. Income and population growth, and technological innovation, will accelerate or decelerate, depending on global location, at the same time that adaptation to climate is taking place. While none of these factors can be considered in isolation, recent research shows that the negative effects of climate change on agriculture are likely overestimated by studies that do not account for economic adjustments or consider the broader economic and environmental implications of such changes.

Based on a collection of research efforts at the farm, national, and global levels, we find that there is considerably more sectoral flexibility and adaptation potential than found in other analyses. The report advances the understanding of these economic adjustments by preliminarily considering them within the broader context of global agricultural environmental sustainability. Specifically,

- Farmers, input suppliers, water managers, food processors, and consumers will adapt to climate change and the market signals resulting from changed agricultural production potential.
 - Farm-level declines in yield without the carbon dioxide (CO₂) fertilization effect, for the major cash crops, have been estimated in previous work at between -4 and -76 percent by the time atmospheric CO₂ doubles. Recent studies that allow for a greater range of adaptation show that yields could increase or decrease (-24 percent to 24 percent) under identical climate scenarios and over the same time period (see chapter 2, table 2.1).
 - For the United States, recent studies that allow for stronger adaptation than earlier work, but no CO₂ fertilization effect, show economic impacts of between -\$11.1 and \$33.1 billion annually, while agricultural producers alone in the United States are impacted by -\$5.8 to \$33.1 billion annually. Work based on crop modeling studies estimated aggregate economic impacts of between -\$67 and \$10.8 billion annually, while agricultural producers are impacted by \$6.6 to \$115 billion annually (see chapter 3, table 3.3).
 - At the global level, where international trade allows disruptions in one area to be compensated by improvements in another, world gross domestic product could increase or decrease by one-tenth of 1 percent (rounded) with adaptation and no CO₂ fertilization effect, a range of -\$24.5 to \$25.2 billion by the time atmospheric CO₂ doubles (see chapter 4, table 4.7). These are longrun equilibrium results that do not consider adjustment costs.

- These results indicate the importance of various assumptions, particularly the level of aggregation used, in the analysis of climate change impacts on agriculture. These results are not a best guess of the effects of climate change on agriculture. A possibly important factor that has been left largely out of the analysis, to facilitate the kinds of comparisons that have been made, is the CO₂ fertilization effect. While there remains scientific controversy concerning this effect, one study estimated CO₂ fertilization to have global benefits of \$119 to \$197 billion over the same time period as the other results (see “CO₂ Effects on Crop Growth,” in Results section of chapter 4, and see figure 1 for the temperature rise and timeframe associated with a doubling of atmospheric CO₂). Other potentially negative offsetting effects could be caused by other greenhouse gases.
- Agriculture must compete with other sectors for land, water, and investments of time and money. If, for example, conditions generally become more arid, competition among agricultural, urban, and industrial users of water would increase. Similarly, shifting of agricultural production to new areas could lead to conversion of grazing, pasture, or forest land to intensive cropland. If such conversions occur, they could contribute to loss of forests and natural ecosystems even as climate change is simultaneously disrupting them.
- Government policies and programs ranging from crop insurance and disaster assistance to acreage reduction programs, tariffs and quotas, and the level of agricultural research will affect the farm sector’s response to climate change by affecting the economic incentives for farmers (and others) to adapt and technological options with which they can adapt.
- Climate change is a global phenomenon; the economic impact of climate change on the U.S. farm sector and consumers depends not only on how production potential is affected within the United States, but also on how changes around the world affect export supplies and import demands in other global regions of the United States’ current and potential trading partners. The negative effects of climate change on agriculture have probably been overestimated by studies that do not account for economic adjustments that would almost certainly be made. The report summarizes and interprets data and conclusions from previous ERS reports on climate change and agriculture.